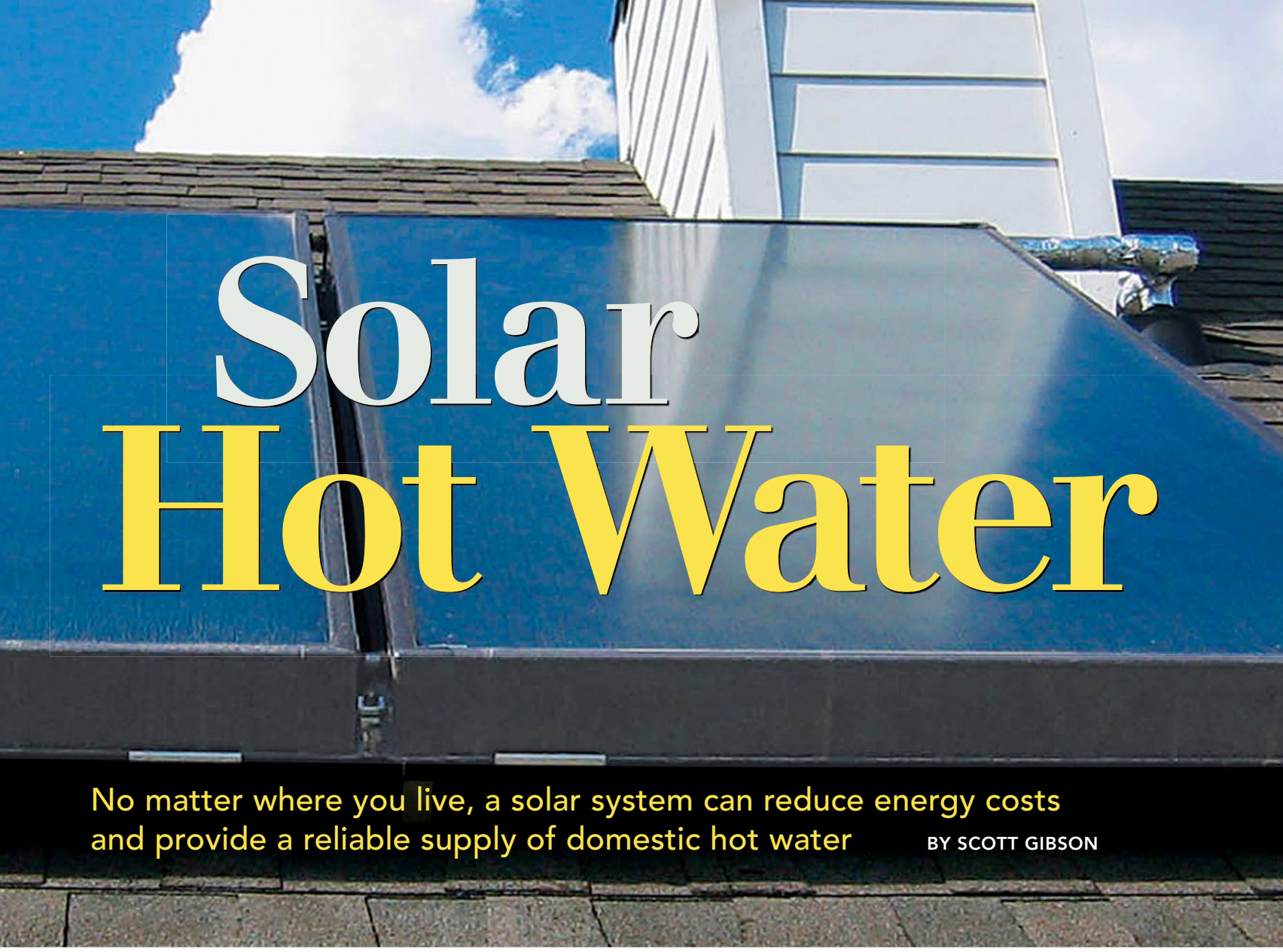


Solar Hot Water

No matter where you live, a solar system can reduce energy costs and provide a reliable supply of domestic hot water

BY SCOTT GIBSON

There's nothing like a looming energy crisis to bring history full circle. More than a century has passed since Clarence Kemp, a Baltimore heating-equipment dealer, came up with the first commercial solar water heater. His patented Climax Solar Water Heater, which sold for $25, was a hit.

More-efficient designs soon came along, and by 1941, half the houses in Florida had solar hot-water systems. Roof-mounted solar collectors were common in California, too. But natural-gas discoveries in the West and a utility blitzkrieg to sell more electricity in Florida brought the solar hot-water business to its knees.

Does the story sound familiar? It should. A spike in energy prices and short-lived government incentives created a solar hot-water boomlet in the 1970s and '80s. The interest withered when energy prices dropped and government subsidies dried up, sticking homeowners with systems that didn't always work and couldn't be serviced for lack of qualified technicians. Rising energy prices are once again making solar attractive. But this time around, the industry is offering more-dependable, better-designed hot-water systems that give homeowners in all parts of the country a reliable way to cut energy bills.

Heating water with the sun can be pretty simple. In the right climate, a 55-gal. drum painted black and perched on the roof provides plenty of hot water. Collectors like that, called batch heaters, are producing hot water all over the world. But technology has a lot more to offer these days, making solar hot water feasible for any region of the country and for just about any application, from swimming pools and hot tubs to domestic hot water and even space heating.

There are many ways to heat water, but keeping it hot is another story

Although solar hot-water systems vary widely in design and complexity, they share some basics. The sun heats water, or another liquid capable of transferring heat, in a collector. Specialized materials called selective coatings are made to absorb available solar radiation. They include black chrome, black nickel, and aluminum oxide combined with nickel or titanium nitride oxide.

Once water is hot, it's moved either to a storage tank or is piped directly to where it's needed. That much seems simple, but the trick is making sure the water doesn't cool down too much or, worse, freeze. To cover the wide range of temperatures and solar potential that hot-

Drawings: Toby Welles/WowHouse.net. Photo this page: Courtesy of Viessmann Manufacturing Co. Inc.

Unobtrusive, efficient, and energy-smart. *Heating water with the sun can be almost as simple as installing the collector on the roof. Resembling skylights, the collectors can provide hot water for baths, laundry, and even heat.*

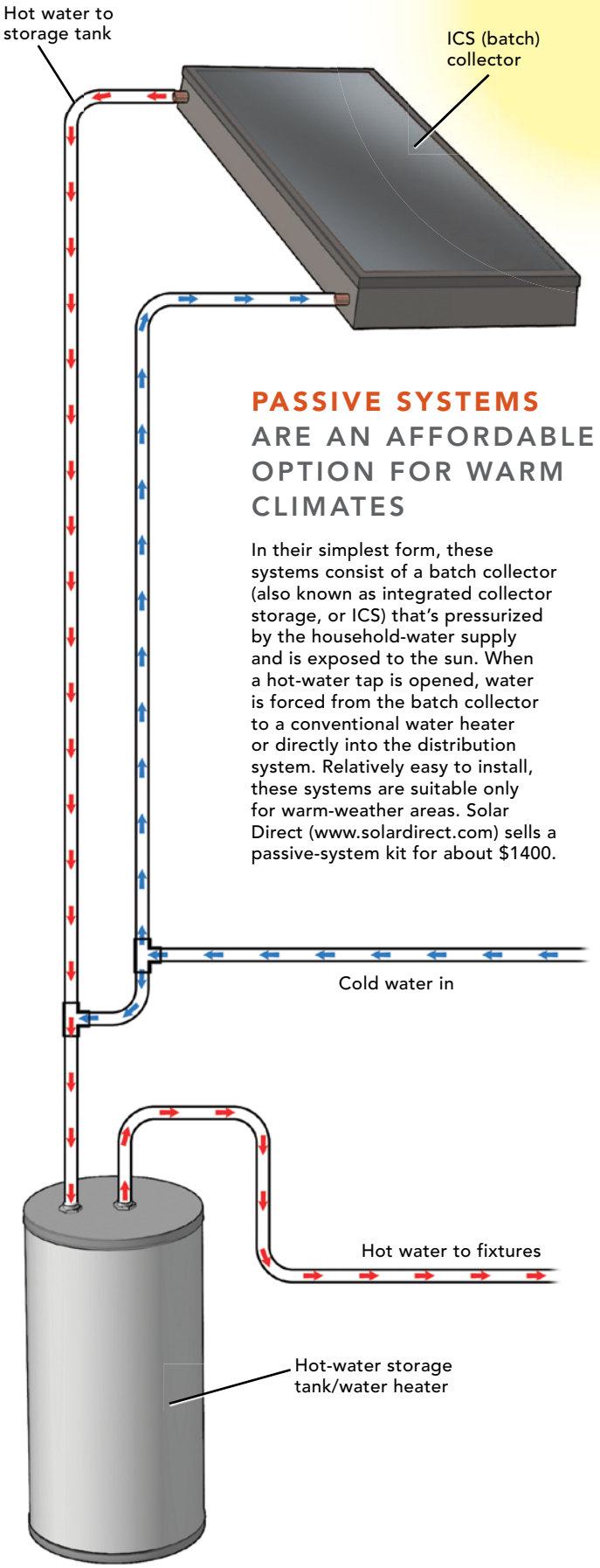
water systems can encounter, manufacturers offer a variety of equipment and plumbing options.

In general, systems are either active or passive, meaning they operate with or without electric pumps. They also can be direct or indirect (sometimes called open loop or closed loop), which means the collectors heat the water that's used in the house or, alternatively, heat a nonfreezing transfer medium that in turn heats potable water in a heat exchanger. In virtually all cases, solar-heated water is routed through a conventional water heater, where it gets a temperature boost before being distributed to its point of use.

How much hot water do you need?

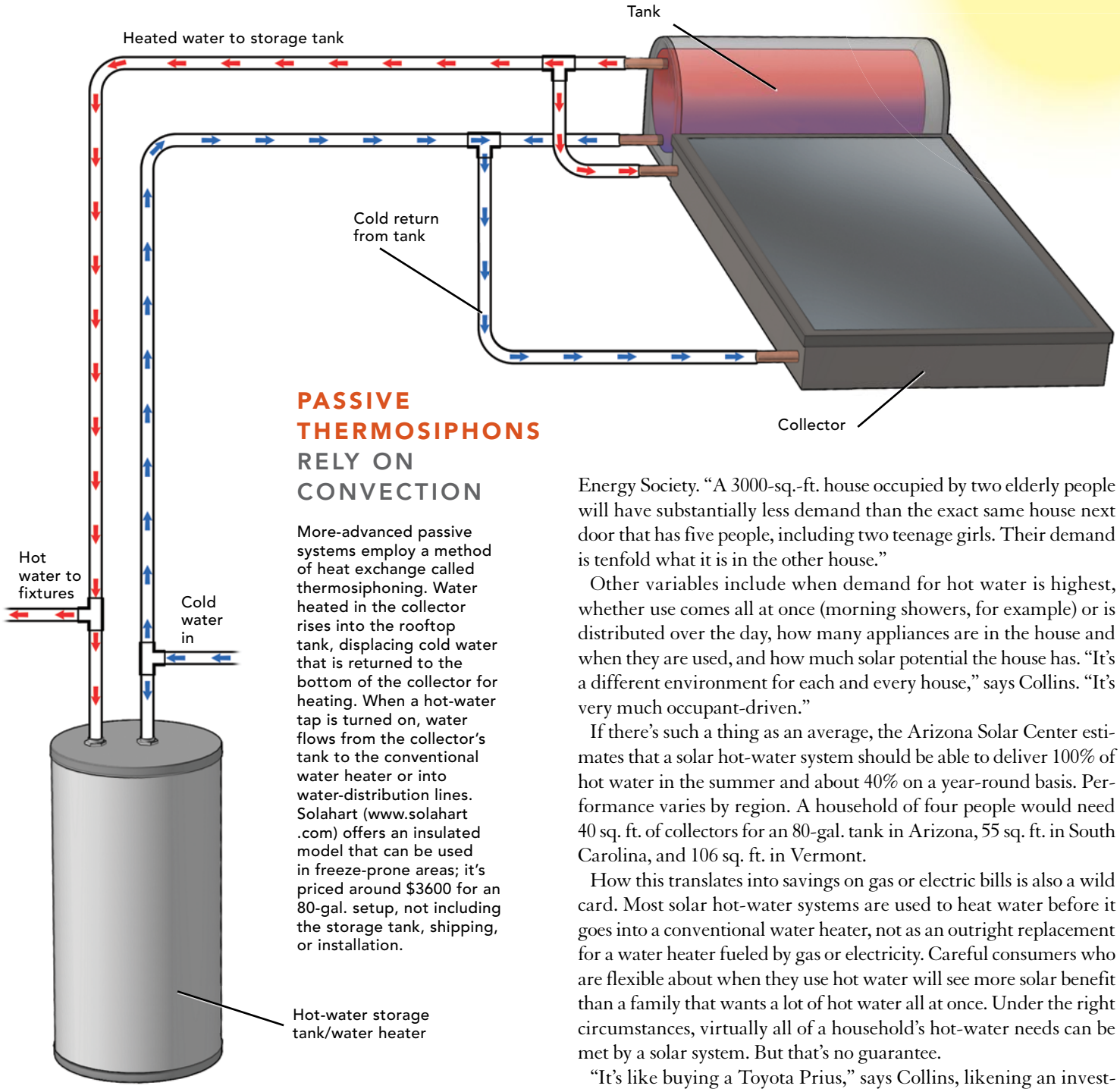
Most Americans use about 20 gal. of hot water a day, a standard industry benchmark. Most hot-water tanks are sized for a single day's consumption, so an average family of four, for example, might end up with an 80-gal. tank. Solar hot-water systems should have no trouble delivering that kind of volume, but there aren't any safe generalizations about whether it will be enough to satisfy household demands.

"The thing with hot water is that there are wide variations in demand," says Brad Collins, executive director of the American Solar



PASSIVE SYSTEMS ARE AN AFFORDABLE OPTION FOR WARM CLIMATES

In their simplest form, these systems consist of a batch collector (also known as integrated collector storage, or ICS) that's pressurized by the household-water supply and is exposed to the sun. When a hot-water tap is opened, water is forced from the batch collector to a conventional water heater or directly into the distribution system. Relatively easy to install, these systems are suitable only for warm-weather areas. Solar Direct (www.solardirect.com) sells a passive-system kit for about $1400.



PASSIVE THERMOSIPHONS RELY ON CONVECTION

More-advanced passive systems employ a method of heat exchange called thermosiphoning. Water heated in the collector rises into the rooftop tank, displacing cold water that is returned to the bottom of the collector for heating. When a hot-water tap is turned on, water flows from the collector's tank to the conventional water heater or into water-distribution lines. Solahart (www.solahart.com) offers an insulated model that can be used in freeze-prone areas; it's priced around $3600 for an 80-gal. setup, not including the storage tank, shipping, or installation.

They work on the ground, too. *As long as the solar exposure is good, it's often easier and less expensive to install large collectors on the ground.*

Energy Society. "A 3000-sq.-ft. house occupied by two elderly people will have substantially less demand than the exact same house next door that has five people, including two teenage girls. Their demand is tenfold what it is in the other house."

Other variables include when demand for hot water is highest, whether use comes all at once (morning showers, for example) or is distributed over the day, how many appliances are in the house and when they are used, and how much solar potential the house has. "It's a different environment for each and every house," says Collins. "It's very much occupant-driven."

If there's such a thing as an average, the Arizona Solar Center estimates that a solar hot-water system should be able to deliver 100% of hot water in the summer and about 40% on a year-round basis. Performance varies by region. A household of four people would need 40 sq. ft. of collectors for an 80-gal. tank in Arizona, 55 sq. ft. in South Carolina, and 106 sq. ft. in Vermont.

How this translates into savings on gas or electric bills is also a wild card. Most solar hot-water systems are used to heat water before it goes into a conventional water heater, not as an outright replacement for a water heater fueled by gas or electricity. Careful consumers who are flexible about when they use hot water will see more solar benefit than a family that wants a lot of hot water all at once. Under the right circumstances, virtually all of a household's hot-water needs can be met by a solar system. But that's no guarantee.

"It's like buying a Toyota Prius," says Collins, likening an investment in solar hot water to owning one of Toyota's hybrid cars. "You change the way you drive because it's rewarding. You see how your involvement can impact your miles per gallon. In the same way, your involvement can impact how much energy you're going to be charged for, whether it's thermal or electrical energy. People become energy literate and smart energy consumers."

Using solar for space-heating

Solar collectors are commonly used for domestic hot water, but they also can supplement both forced-air and hydronic-heating systems. In Europe, says Tim Merrigan of the National Renewable Energy Laboratory in Boulder, Colo., package systems that do both are relatively common. But due to heavy winter-heating loads and reduced solar

Photo this page: Courtesy of Rheem Manufacturing Co.

potential, homeowners in this country shouldn't expect to get much more than one-third of their winter heat from solar sources with today's technology.

Elia Kleiman, the president of Synepex Energy in Cambridge, Mass., says the proportion of winter heat from solar depends on the type of heating system, the amount of insulation installed, and the tightness of the house. A best-case scenario in New England, land of snowy winters and cold, dreary springs, is that a solar system meets 40% to 70% of the heating load. That's in a well-sealed house with a radiant-floor heating system.

Radiant-floor heating is especially well suited to solar hot-water systems because it requires lower water temperatures, 120°F versus the 180°F that would be pumped through a typical baseboard hydronic system. Solar hot water also can be used for newer forced-air systems that use a technology called "hydro air." These boilers heat water forced through a heat-transfer coil, where it warms outgoing air. (For more info, see "Downsizing for Comfort," *FHB* #187, and online at FineHomebuilding.com.)

For a hypothetical house of roughly 2500 sq. ft.—well insulated and well sealed—Kleiman says Synepex would probably recommend eight evacuated-tube collectors covering roughly 400 sq. ft. of roof. That would provide 100% of domestic hot water in addition to what it supplied to the space-heating side.

Systems like that aren't cheap. Although it's difficult to offer meaningful numbers without knowing specifics, Kleiman says that a solar-radiant floor system could easily cost $16,000 and possibly as much as $24,000 before tax credits and rebates. That's many times more than a system designed for only domestic hot water. If the collectors were tied to a baseboard hot-water system rather than radiant floor, a homeowner might expect to see solar take care of only 20% to 40% of the heating load.

A big drawback with trying to heat the house with solar hot water is that demand is highest when the heat potential of the system is lowest. On an overcast day in northern New England, the sun is long gone by late afternoon, and the call for heat goes up accordingly. The answer

How much will my system cost?

Cost is a key consideration when weighing the merits of renewable energy, not only because the systems tend to be expensive but also because they force us to think about energy in an entirely different way. A conventional water heater doesn't cost much, but it's expensive to operate over its lifetime. A solar hot-water system is much more expensive up front but costs less to use.

Thinking in generalities isn't helpful when it comes to deciding whether solar hot water is a reasonable investment. For specifics, I went to www.findsolar.com, a Web site run under the auspices of the Department of Energy, the American Solar Energy Society, and the Solar Electric Power Association. It's an excellent place to get started on a hot-water system and provides a variety of other useful links.

A worksheet let me plug in a lot of specifics: my state, county, electric utility, and the number of people living in the house. In just a few seconds, the site came up with the size of the system I'd need, length of payback, annual utility savings, and even return on investment.

1. In southern Maine, I'd need one collector of about 32 sq. ft. to produce the 35 gal. of hot water my wife and I would use in a day. Having the system installed would cost about $3500, but after a state rebate and the federal tax credit, the net cost would be less than half that. Moreover, my property value would increase by as much as $3690, my annual utility savings would be from $224 to $335, and I would remove 21 tons of greenhouse gases from the air. That's the equivalent of 42,000 auto miles.

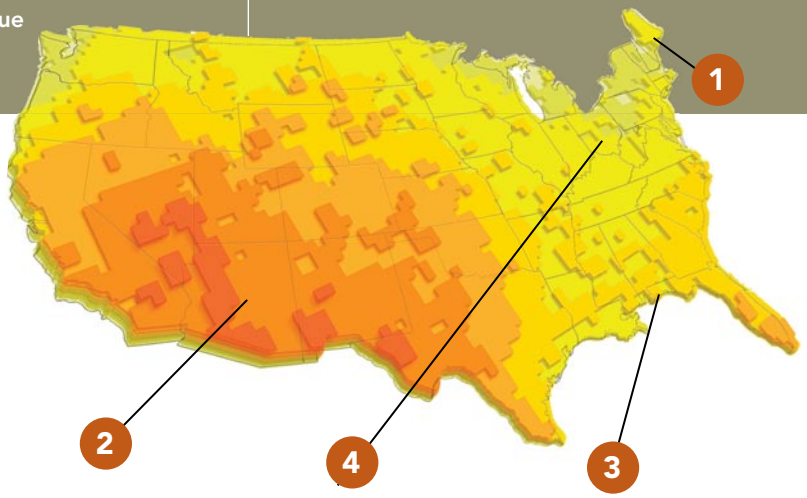
Years to break even? Between three and four, not including the system's impact on property-value appreciation. If I wanted estimates, a link would take me to a list of local installers, complete with contact information, services offered, and a brief summary of their experience.

2. In Tucson, Ariz., where utility rates are lower, a similarly sized system would produce between $252 and $378 in annual utility savings.

3. In Pensacola, Fla., lower state incentives and utility rates drive the savings down to a range between $74 and $110.

4. In Dayton, Ohio, the savings are about the same as in Pensacola (about $85 per year).

If electricity rates increase more in the future than now forecast, solar hot water will become a viable option for more people. Until then, when it comes to saving money with solar hot water, it seems that if you have high utility rates, you'd be smart to get a system on your roof. If not, the decision depends on your commitment to a cleaner environment.



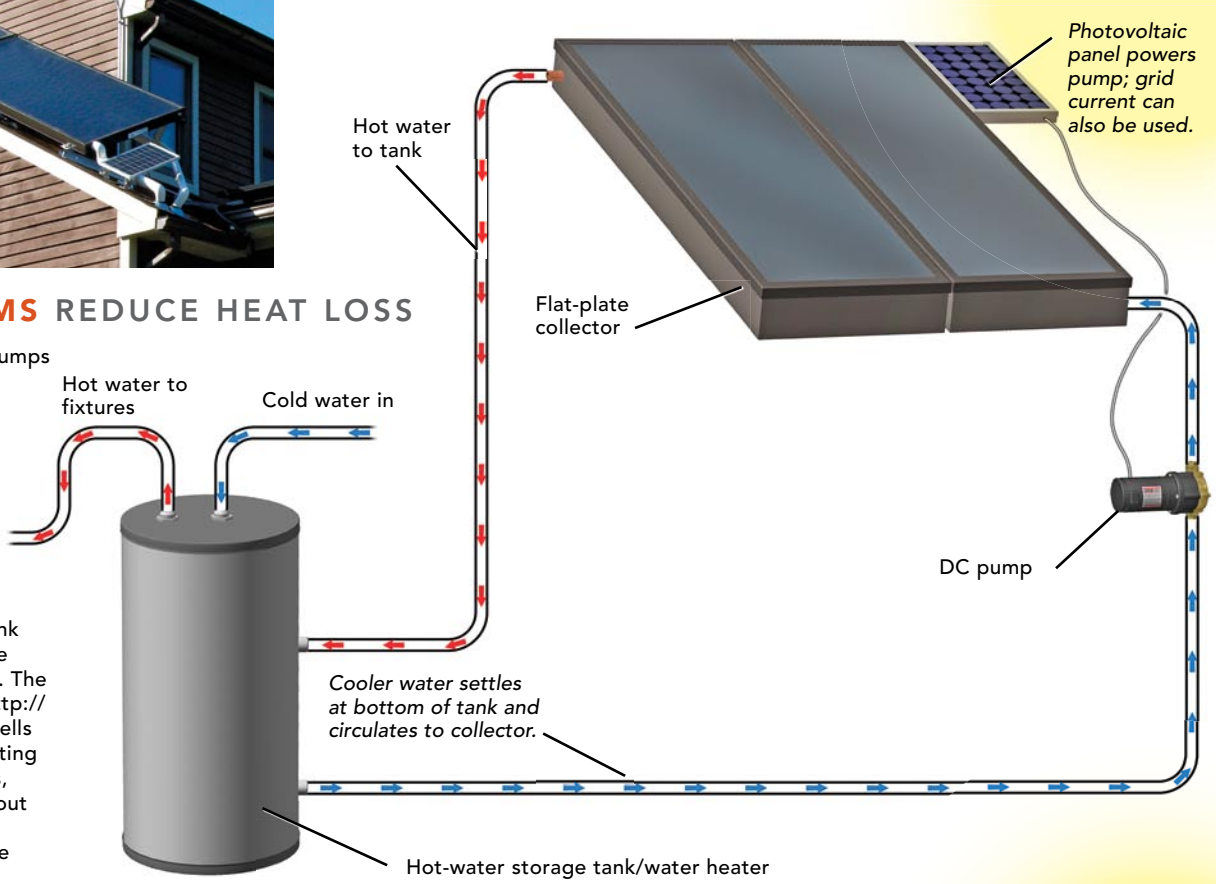
kwh/m²/day kilowatt hours per square meter per day

4-4.5 4.5-5 5-5.5 5.5-6 6-6.5 6.5-7

Map indicates an annual average of daily solar-radiation potential for a south-facing flat collector array, mounted at an angle equal to its latitude. Data courtesy of National Renewable Energy Laboratory.

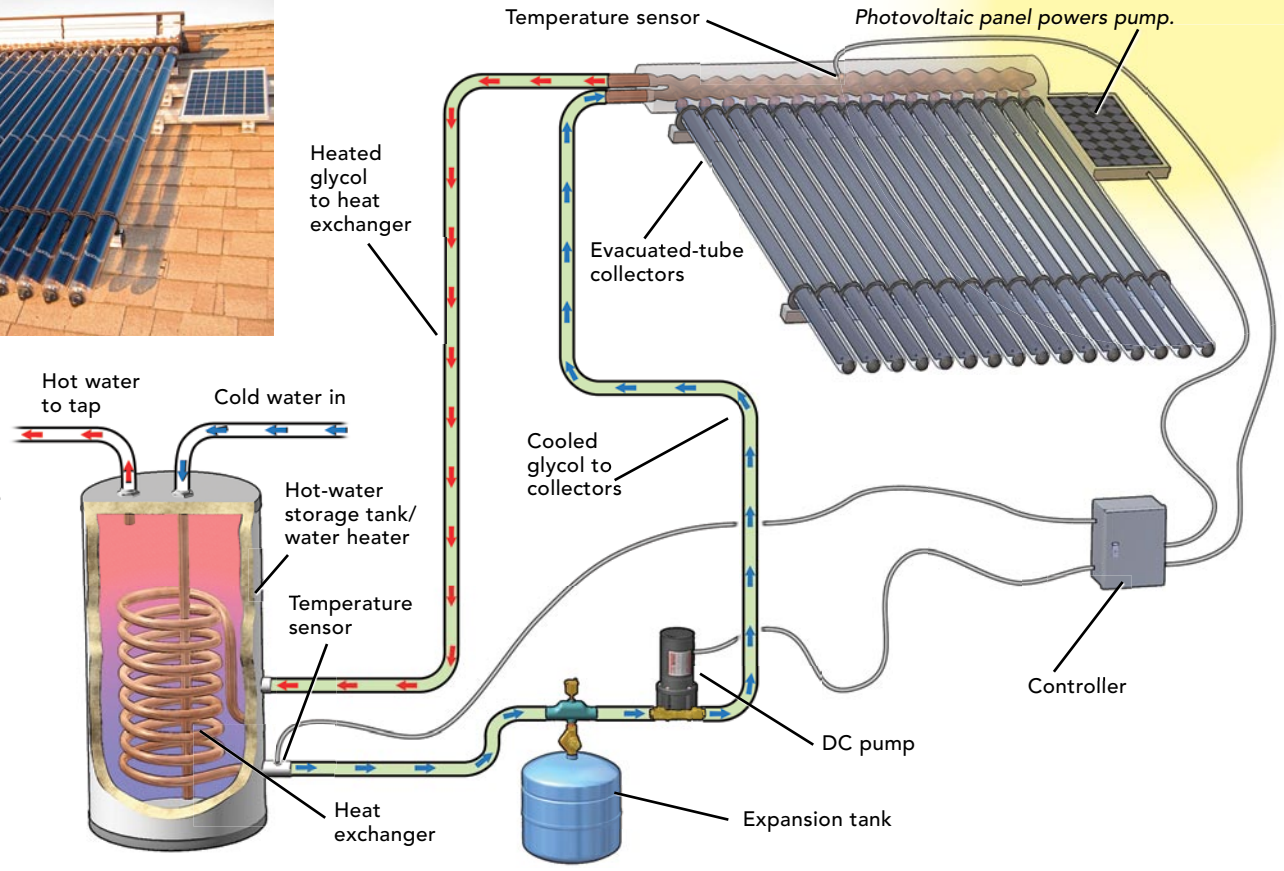
ACTIVE SYSTEMS REDUCE HEAT LOSS

In active systems, electric pumps speed circulation to reduce heat loss. As illustrated here, water is run through flat-plate collectors (essentially heat collectors plumbed with a network of copper pipe) to the water heater. In areas subject to occasional freezing, water is drained into a secondary storage tank when the water temperature drops below a certain point. The Alternative Energy Store (http://home.altenergystore.com) sells a basic open-loop kit consisting of three flat-plate collectors, hardware, and pump for about $3600. The storage tank, shipping, and installation are not included.



INDIRECT SYSTEMS ARE MOST EFFICIENT AND MOST EXPENSIVE

In these active systems, a pump circulates glycol in a closed loop. After running through high-efficiency evacuated-tube collectors (or flat-plate collectors), the hot glycol returns to the storage tank, where a heat exchanger warms potable hot water. Essentially freezeproof, these glycol-charged systems are able to perform in any season. Energyworks LLC in Portland, Maine, put the price of an installed system adequate for a local family of four at about $10,000.



Photos this page: Courtesy of Solarwrights Inc.

Collector installation at a glance

Solar hot-water systems involve a fair amount of labor-intensive planning and plumbing, but a typical collector installation is fairly straightforward. On this membrane-covered shed roof, 1 the first step was to erect the aluminum frames that hold the panels. The frames are adjusted to a fixed angle that maximizes the collector's solar gain and are bolted to blocking that has been integrated into the roof. 2 The panels, which weigh about 100 lb. each, are carried up and clipped onto each pair of frames. 3 Simple compression fittings connect the panels to plumbing. 4 The installers added two more panels and finished in about half a day. They spent another two days setting up the system.

is to store hot water generated during the day in storage tanks so that it can be used for heat when the sun goes down or when the days are cloudy. Tanks can be very large, 2000 gal. or more, although Kleiman says newer systems can use much-smaller tanks, as little as 200 gal.

Researchers also are looking down the road at promising new possibilities. Merrigan, for example, describes one experimental project in Canada where solar collectors are used to heat the ground when solar potential is abundant in summer. In winter, geothermal heat pumps can be used to extract the stored heat. This seasonal storage of heat is one idea that could make 100% solar heat possible in the future—even in Calgary, Alberta.

Rebates and tax breaks could be the keys to the future

What takes the sting out of the high cost of buying into renewable-energy systems is a combination of federal tax credits and state and utility rebates. The federal credit, now pegged at 30% of system cost up to a maximum credit of $2000, is open to everyone. State and utility rebates, however, vary. Where they are generous, such as in California or Hawaii, you can expect robust growth for the solar industry.

The federal credit is now scheduled to end in 2008. Although pending legislation would extend the program, the on-and-off nature of government support is a "travesty," says Collins, and a chronic problem for the solar industry. "You can't do this with stops and starts," he adds. "It's been the history of incentives for renewables for the past 25 years."

Merrigan says that as many as 35% of all houses in Hawaii have solar water-heating systems, in part because of generous rebates. "I think it's key," he says. "It's just like for photovoltaics. PV is growing where there are incentives. The first cost of the system can be enough to make people think about it, but to not want to make that investment. If you have incentives that can bring down that first cost, you see good market penetration."

Still, credits and incentives are available now, and they make a much-bigger difference proportionally for hot water than for photovoltaic systems. "You displace roughly 2 kw of energy with your water system, so it's like putting a 2-kw PV system on your roof," says Collins. "But its hot water. A 2-kw system of PV might be $20,000, but a 2-kw solar hot-water system might be $6000. I've often said that solar hot water is the most misunderstood bargain out there." □

Contributing editor Scott Gibson lives in East Waterboro, Maine. Photos by Charles Bickford, except where noted.

RESOURCES FOR SOLAR INFO

Alternative Energy Store
http://home.altenergystore.com
Solar information and products.

American Solar Energy Society
www.ases.org
Links, background information on solar energy.

Find Solar
www.findsolar.com
Worksheets for estimating costs of solar hot-water systems.

Florida Solar Energy Center
www.fsec.ucf.edu
Comprehensive site on all things solar, including efficiency ratings of collectors and systems by manufacturer.

Interstate Renewable Energy Council
www.irecusa.org
Includes a state-by-state listing of energy incentives.

National Renewable Energy Laboratory
www.nrel.gov
Lots of background information on renewable energy.

Solar Direct
www.solardirect.com
Solar information and resources.

Solar Rating and Certification Corp.
www.solar-rating.org
Ratings for solar collectors and systems by manufacturer.